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GLM and WTLMA flash rate and energy analyses

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GLM Science Meeting, Huntsville, AL
12-14 September, 2017

INTRODUCTION

Goal: Exercise GLM data with time seres and gridded analyses

- Trends, cells drive many meteorological applications

GLM Level 2 data; operational production environment (OE)

WTLMA post-processed (80 μs) data

Uncertainty: which LMA flashes will GLM see?

- Skip cross-dataset association; look at counts on same grids, same times

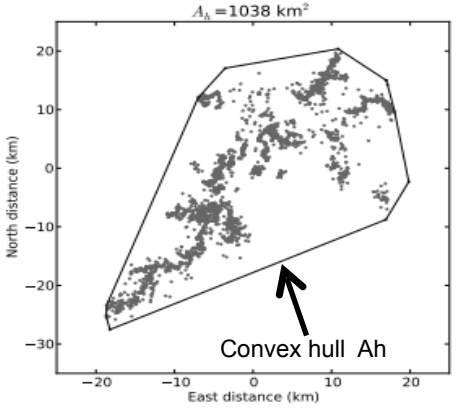
Reframe problem: which LMA flashes must we discard to reach *x* % DE?

- Probability of seeing a GLM flash with certain energy and area properties given an LMA flash with certain area and altitude properties

- Flash energy is proportional to LMA flash area (Bruning and MacGorman 2013)

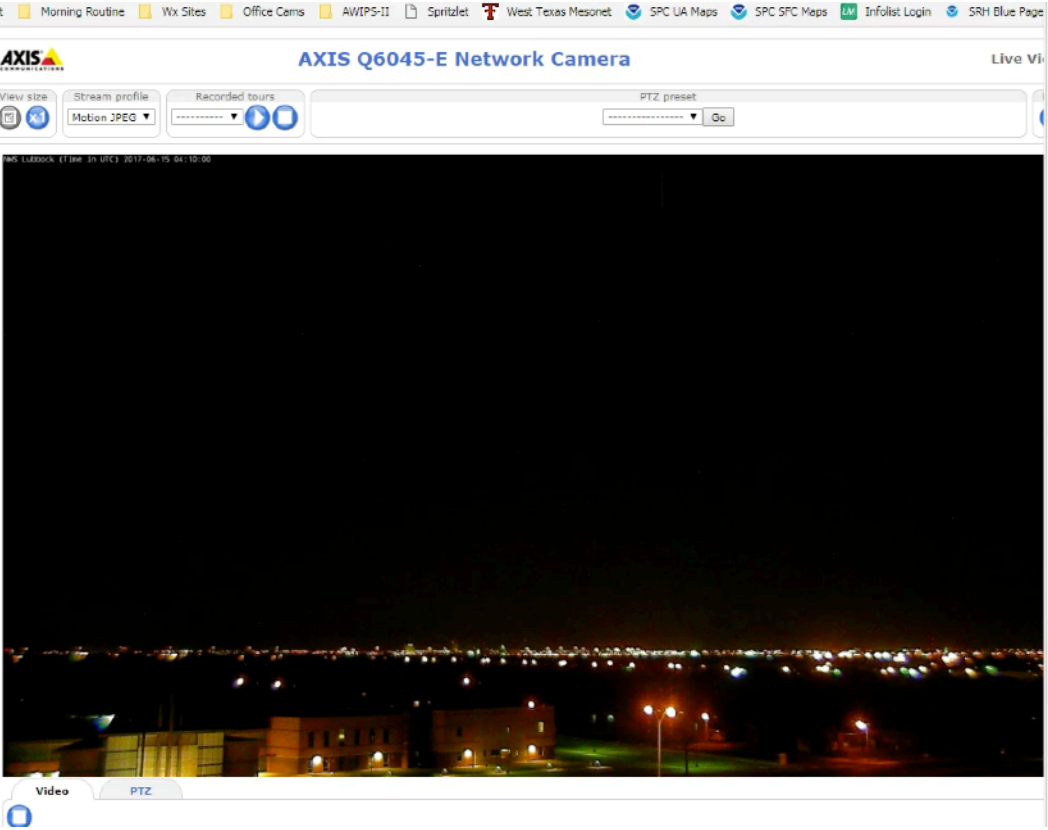
$$l = \sqrt{A_h}$$

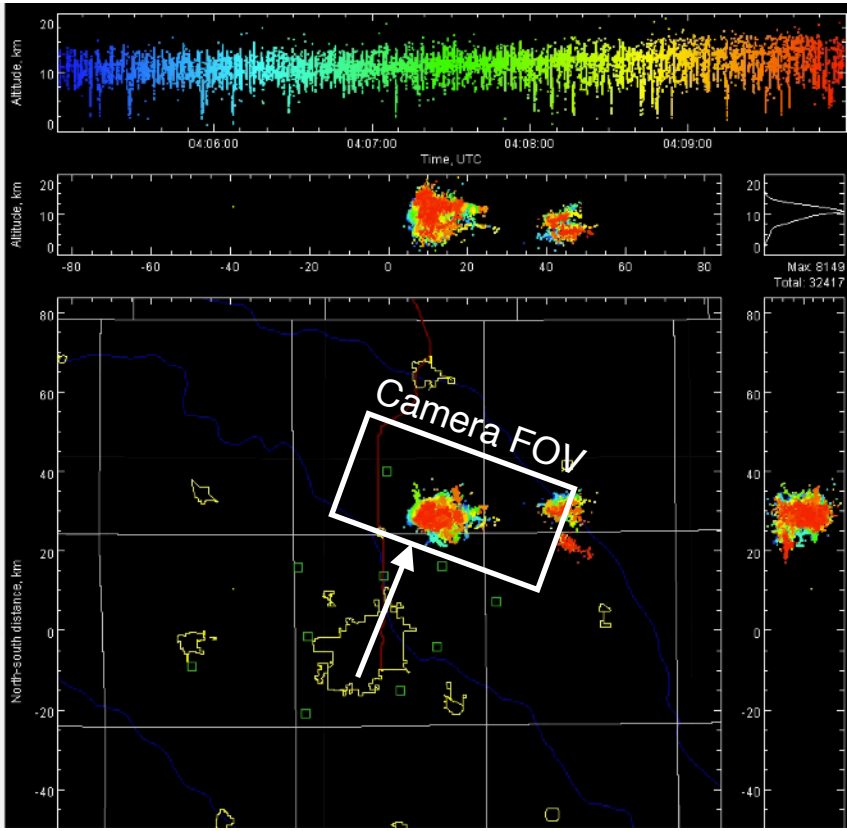
$$E(l) = \frac{\rho^2 l^2 d^3}{2\epsilon_0} = Kl^2$$



0410 UTC, 15 June 2017 - Webcam and LiveLMA
Jason Jordan, NWS Lubbock (full 30 min avail.)

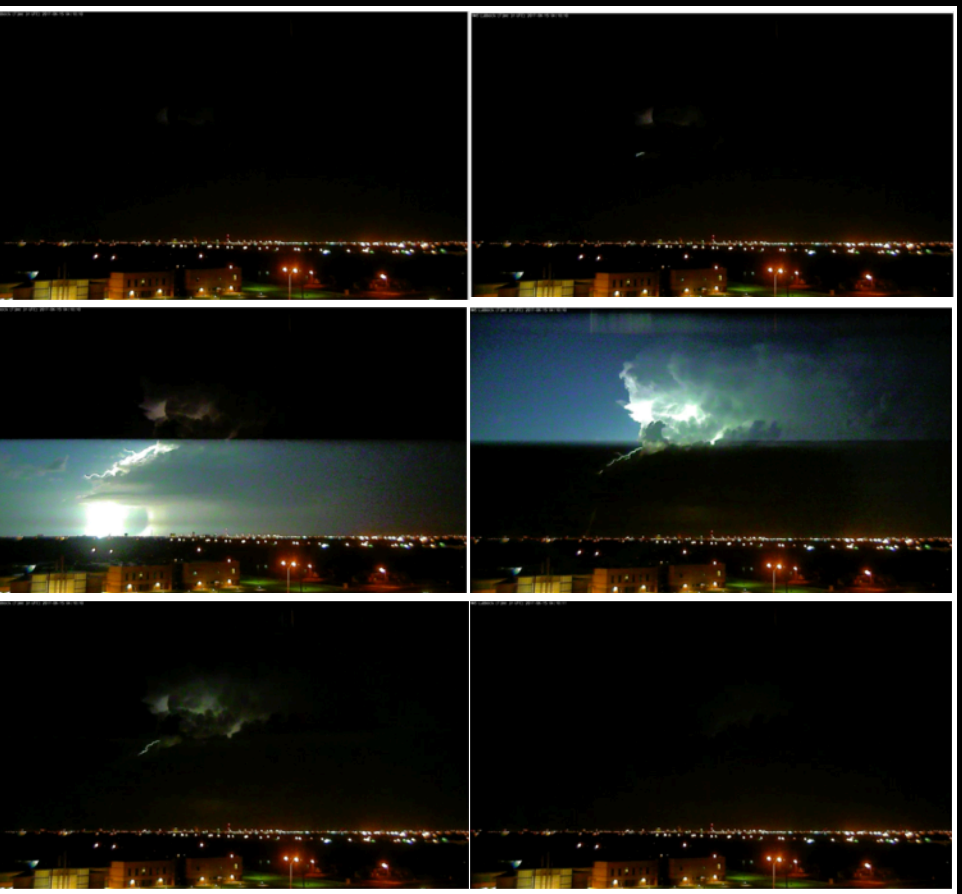
1-2 sec lag

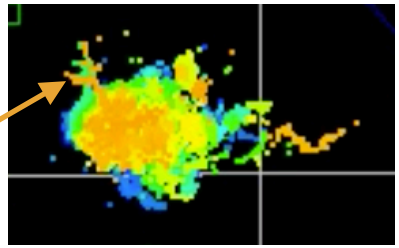




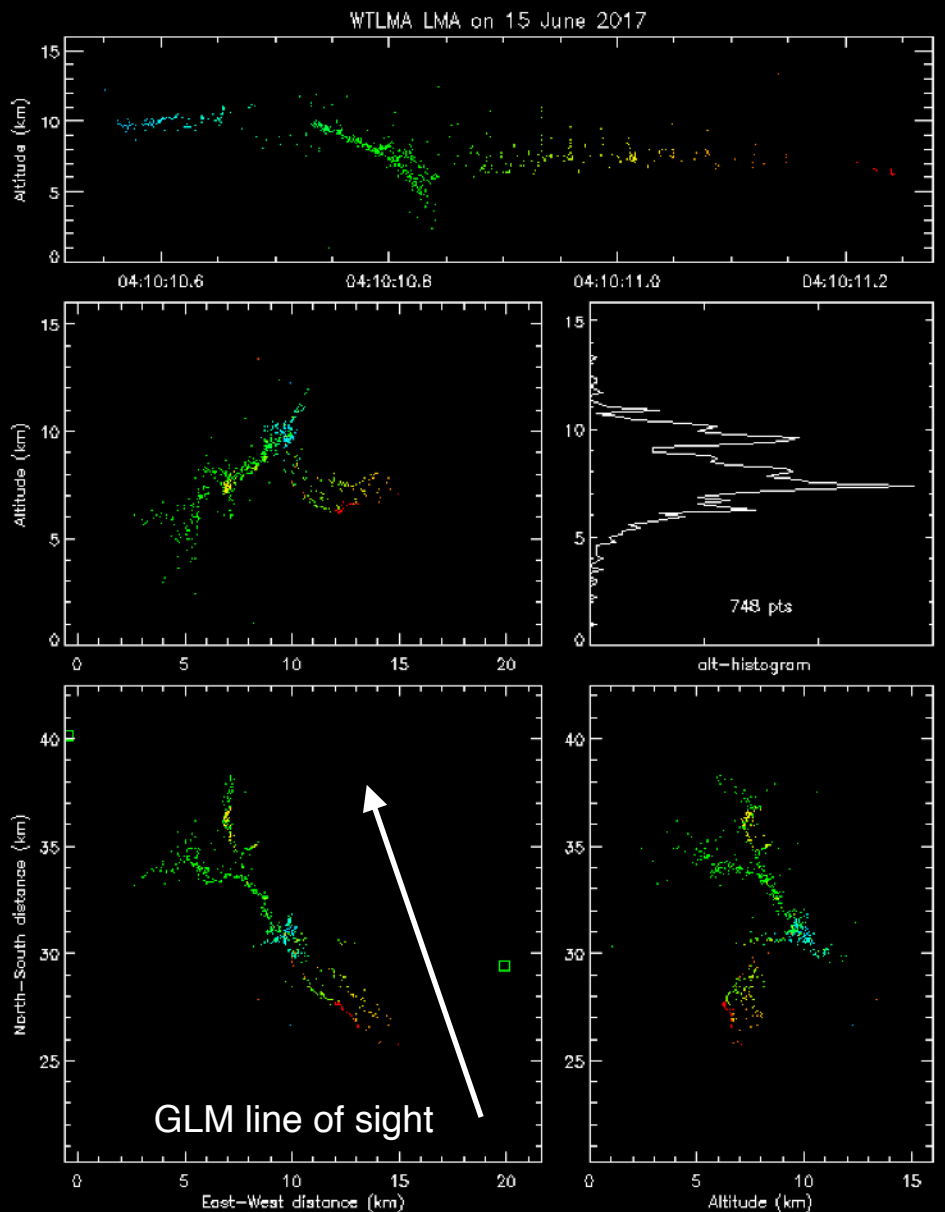
- In 17 s video, 10 LMA and video flashes
- Four flashes were reported by GLM
- LMA with GLM and video frames from other flashes are on the cal/val portal
- Bolt from the blue not reported by GLM!

Bolt from the blue is dim at cloud top and hidden by line of sight through cloud

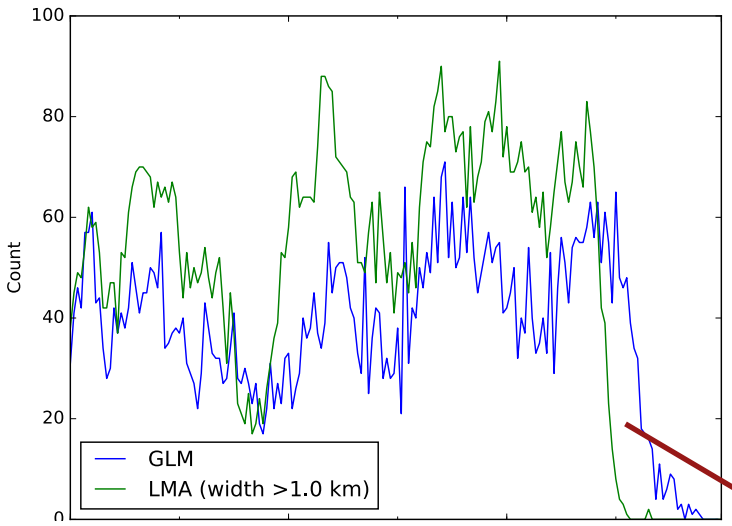


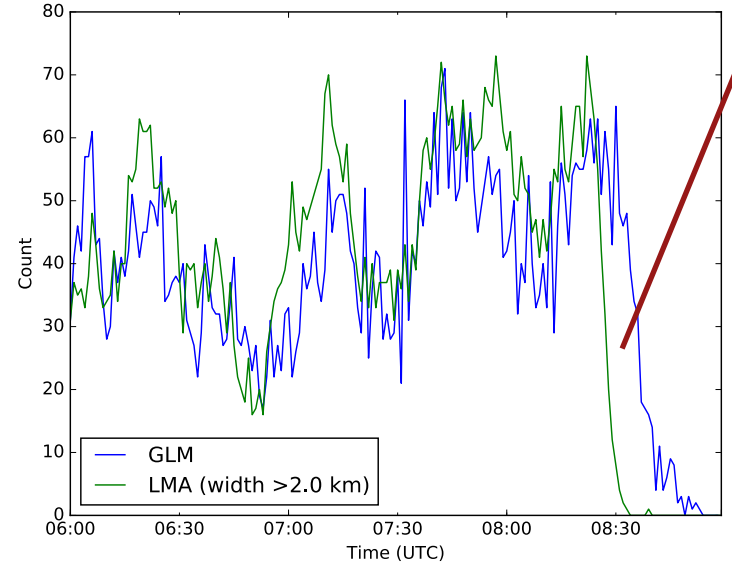


Strike of interest is behind bulk of storm



29 April 2017, West Texas (post-DO 04.04.01)
Effect of LMA flash area filter on relative DE

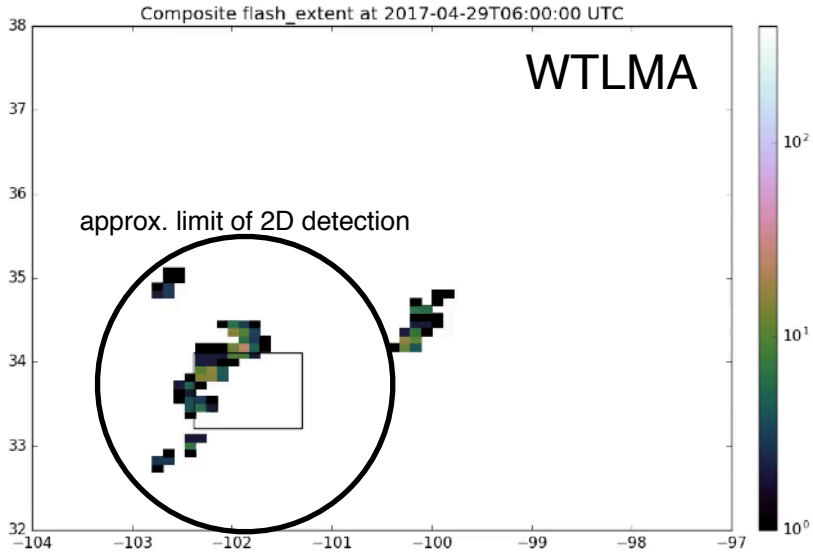


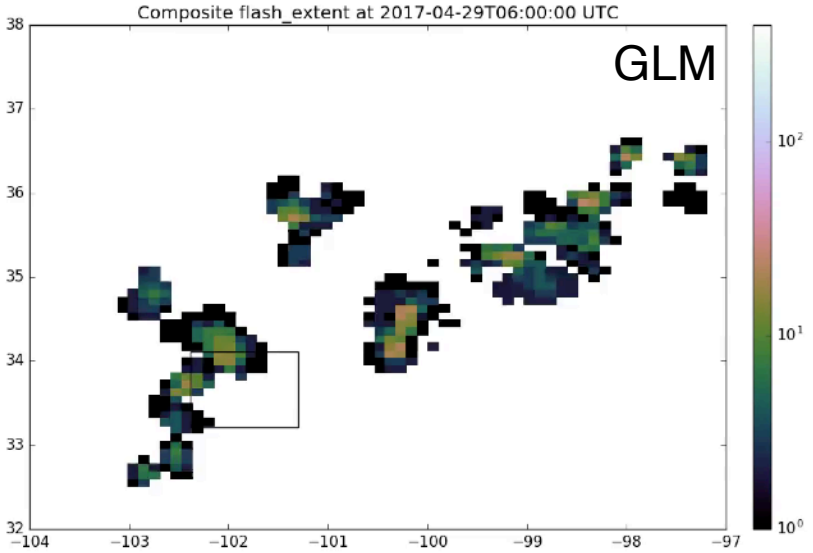


Flash counts are for the interior rectangle, directly over the WTLMA

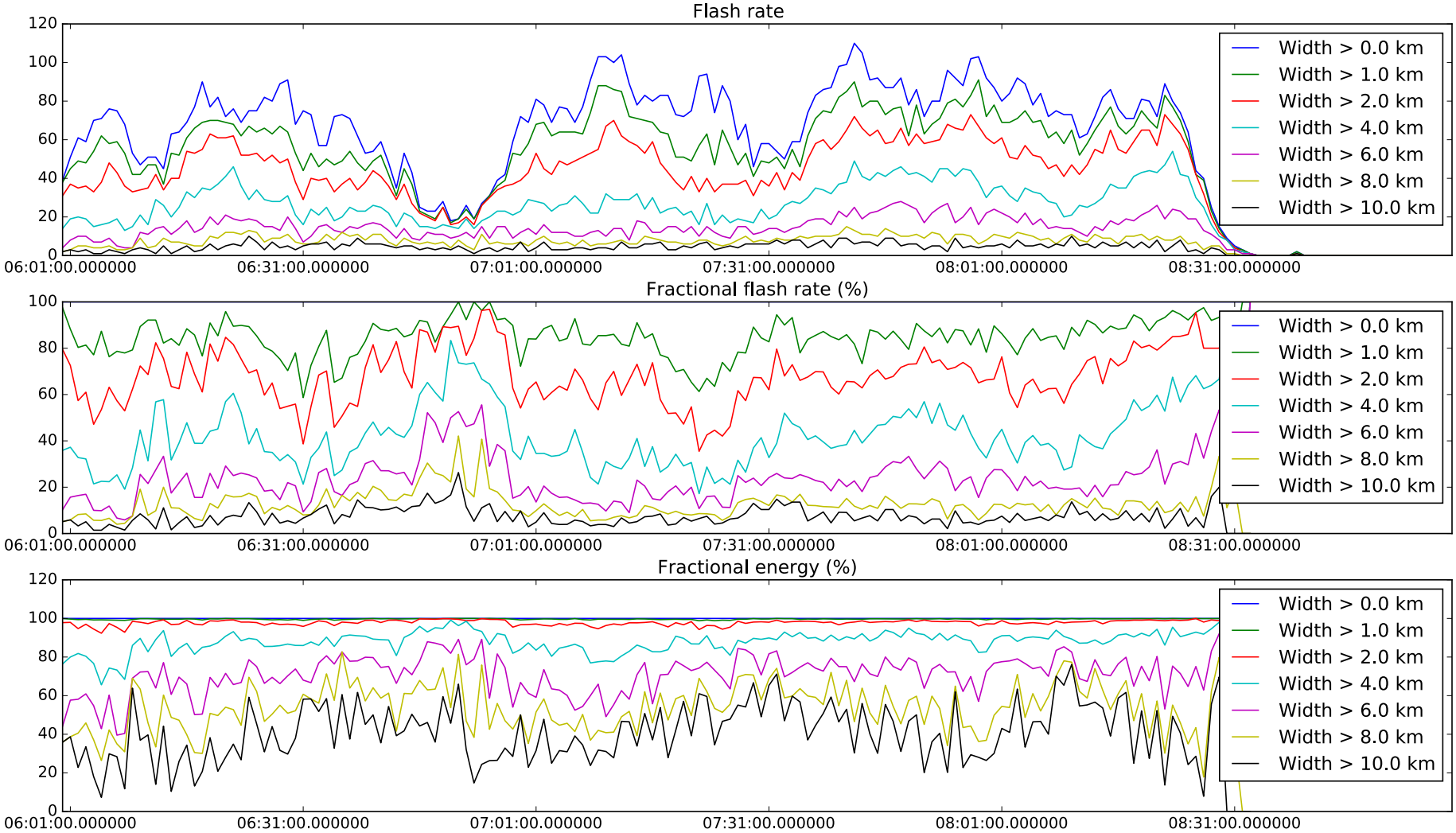
Southwest offset of storm location causes the GLM flash rate to lag as storm exits analysis box

Trends are similar, and rates are much closer if small LMA flashes are removed





Energetic justification for removal of small flashes (29 April 2017, WTLMA)

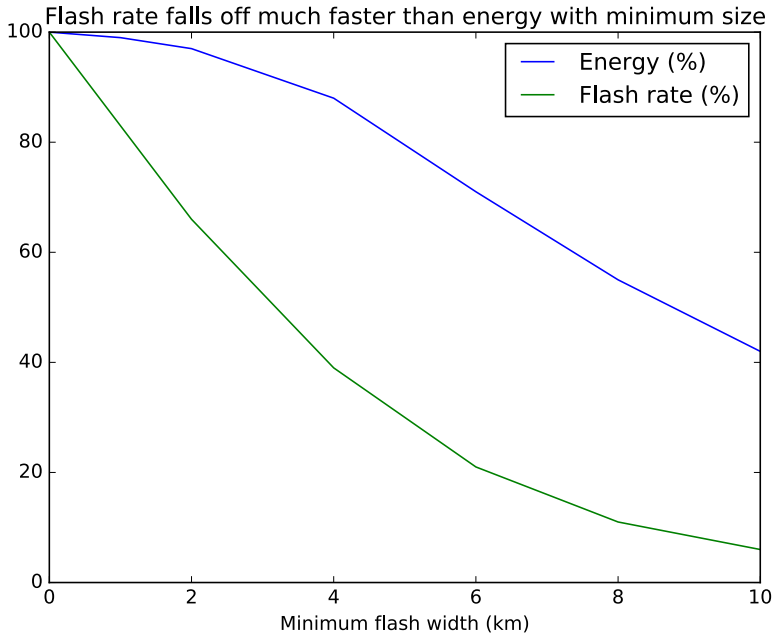


- Flash energy is proportional to LMA flash area (Bruning and MacGorman 2013)

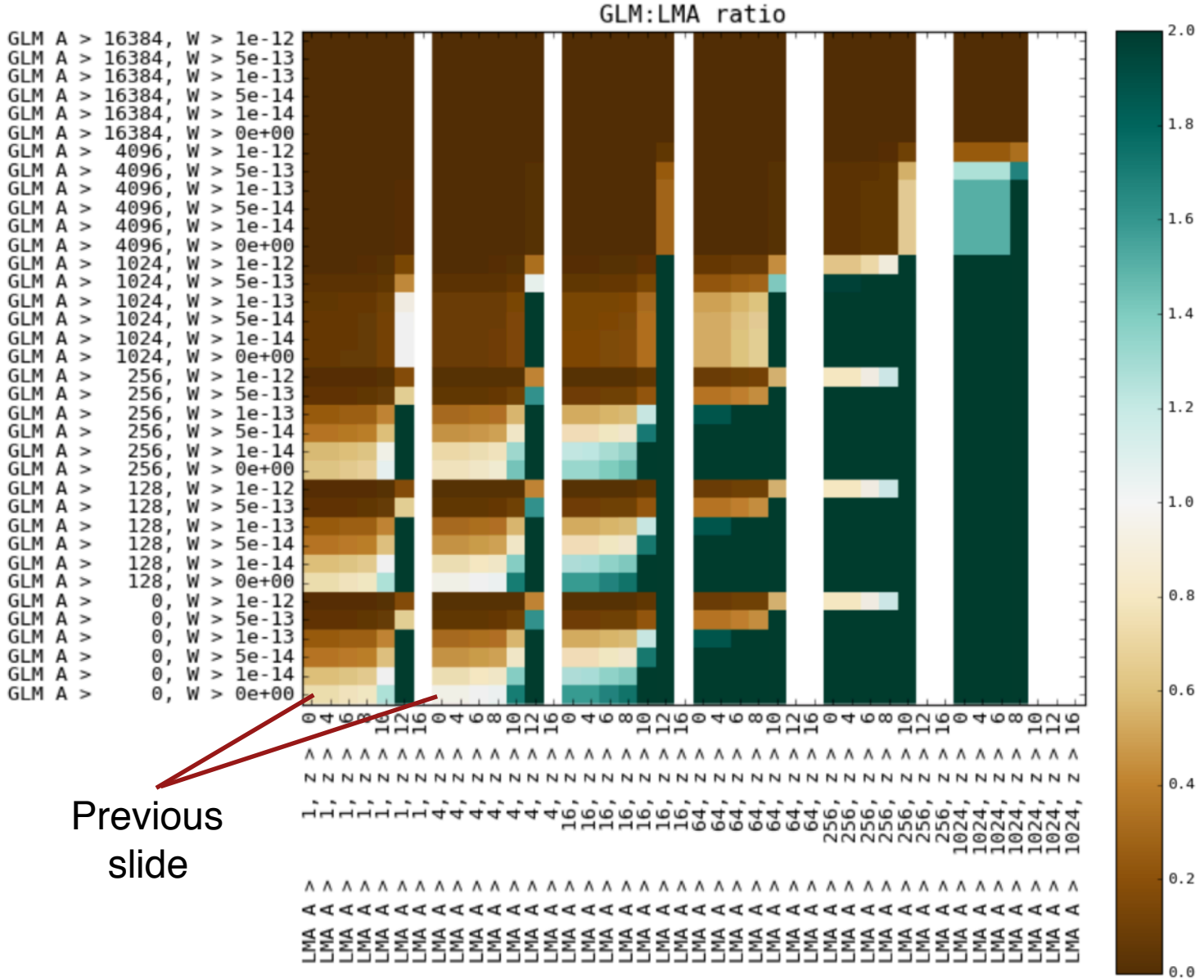
29 April 2017 - WTLMA

- We can discard small LMA flashes and preserve a large fraction of the energetic signal
- Recommended as an LMA QC step for any bulk analyses

Min LMA area	1 km	2km
LMA flash rate decrease	15%	34%
LMA energy decrease	1%	3%
GLM DE	**76%**	**95%**



29 April 2017, West Texas
GLM: area & radiant energy
LMA: area & altitude



Previous slide

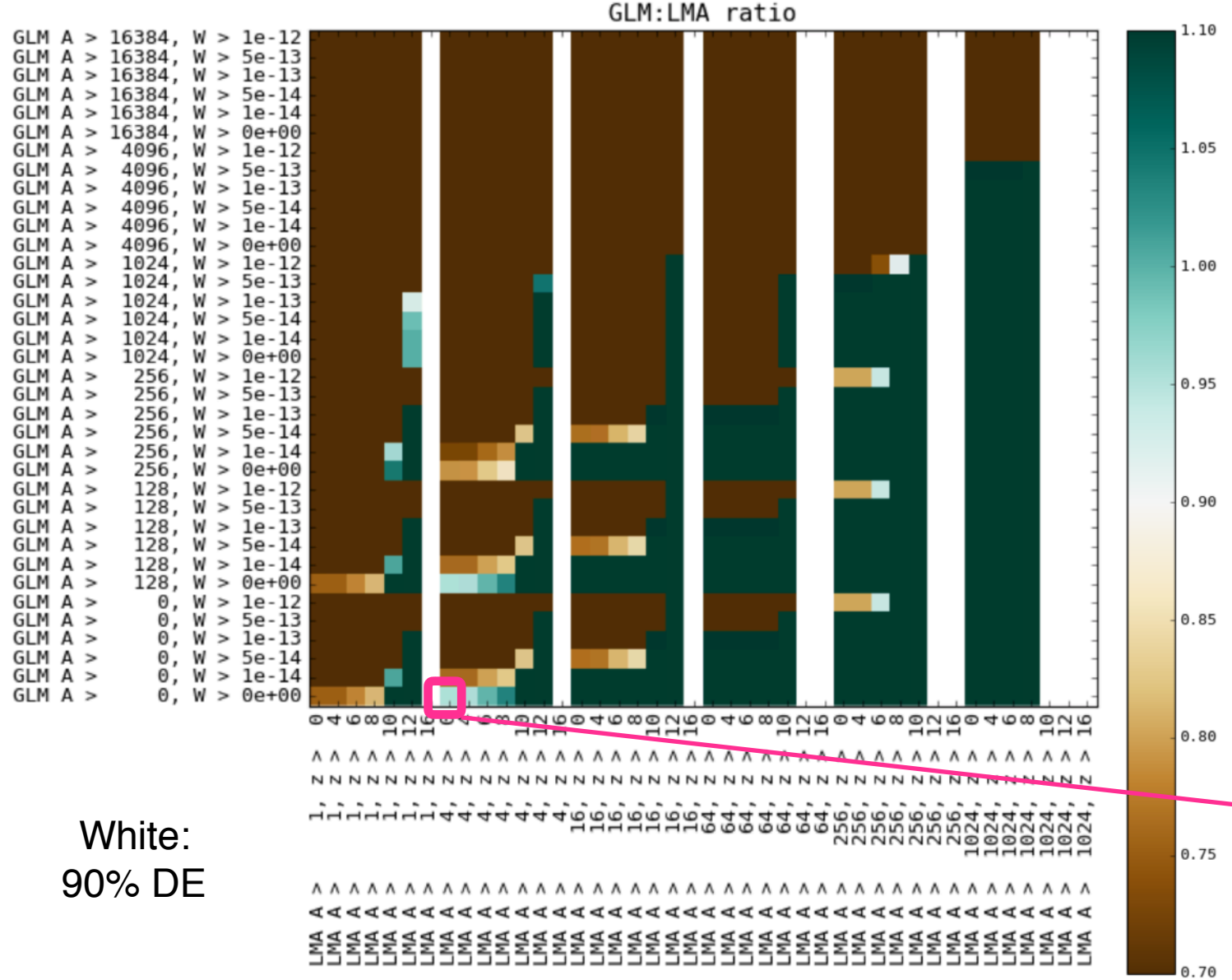
Each square is based on time series data in same box over WTLMA

Upper left: LMA sees more

Lower right: GLM sees more

95% DE of all LMA flashes with width > 2 km

29 April 2017, West Texas
GLM: area & radiant energy
LMA: area & altitude



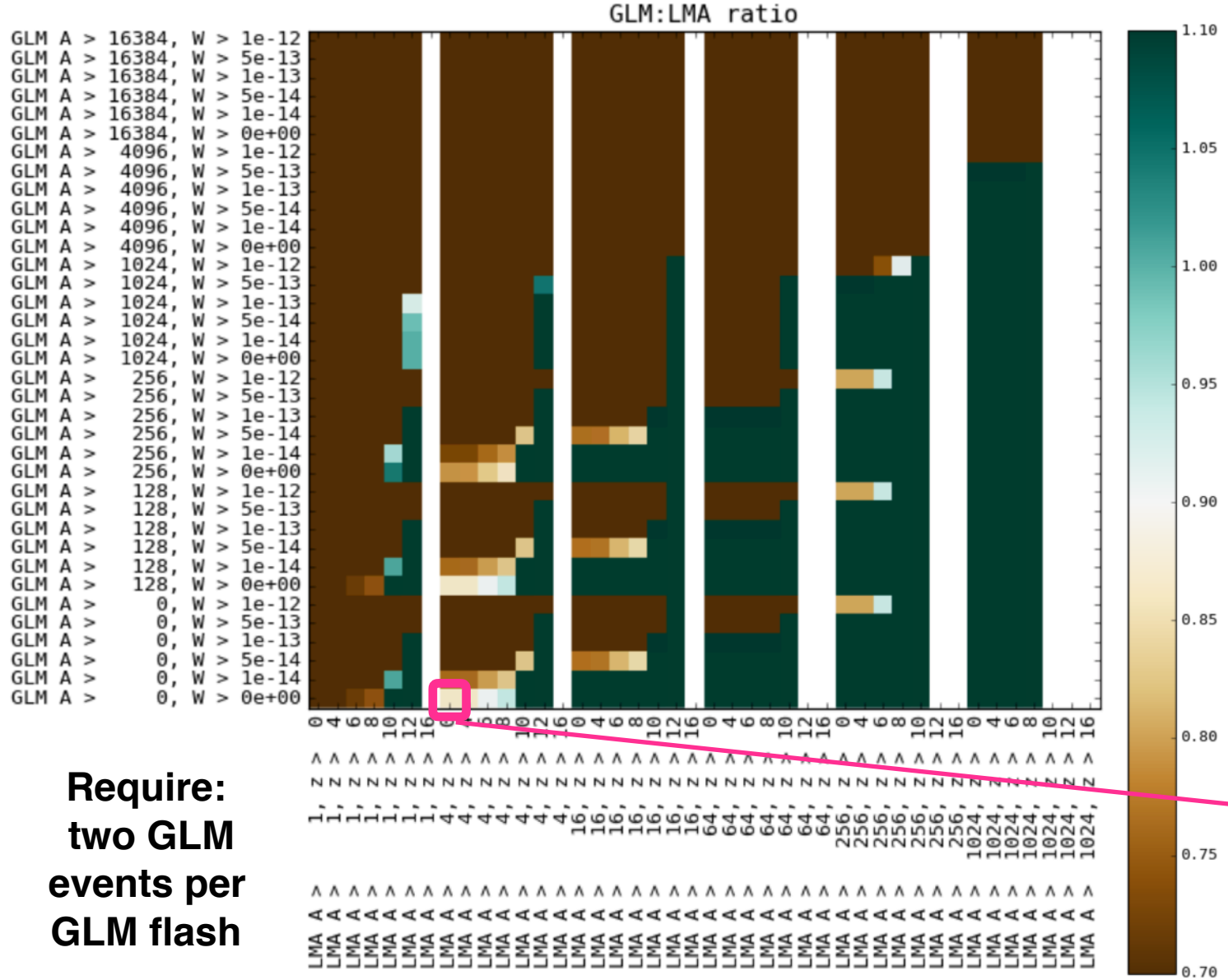
White:
90% DE

Each area sub-block has a 1:1 sweet spot

As expected, some small or low-altitude flashes are not observed by GLM

95% DE of all LMA flashes with width > 2 km

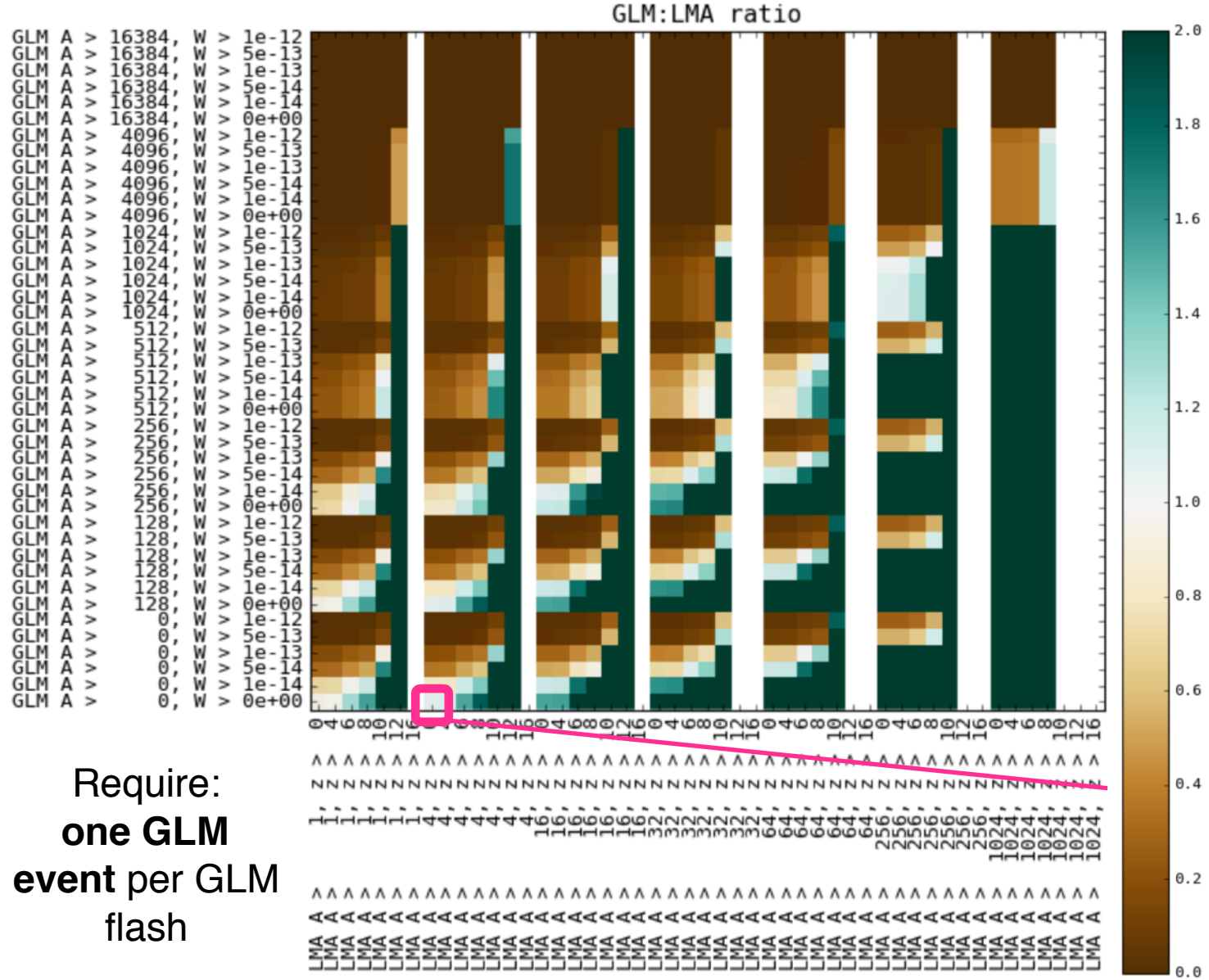
29 April 2017, West Texas
GLM: area & radiant energy
LMA: area & altitude



Require: two GLM events per GLM flash

87% DE of all LMA flashes with width > 2 km

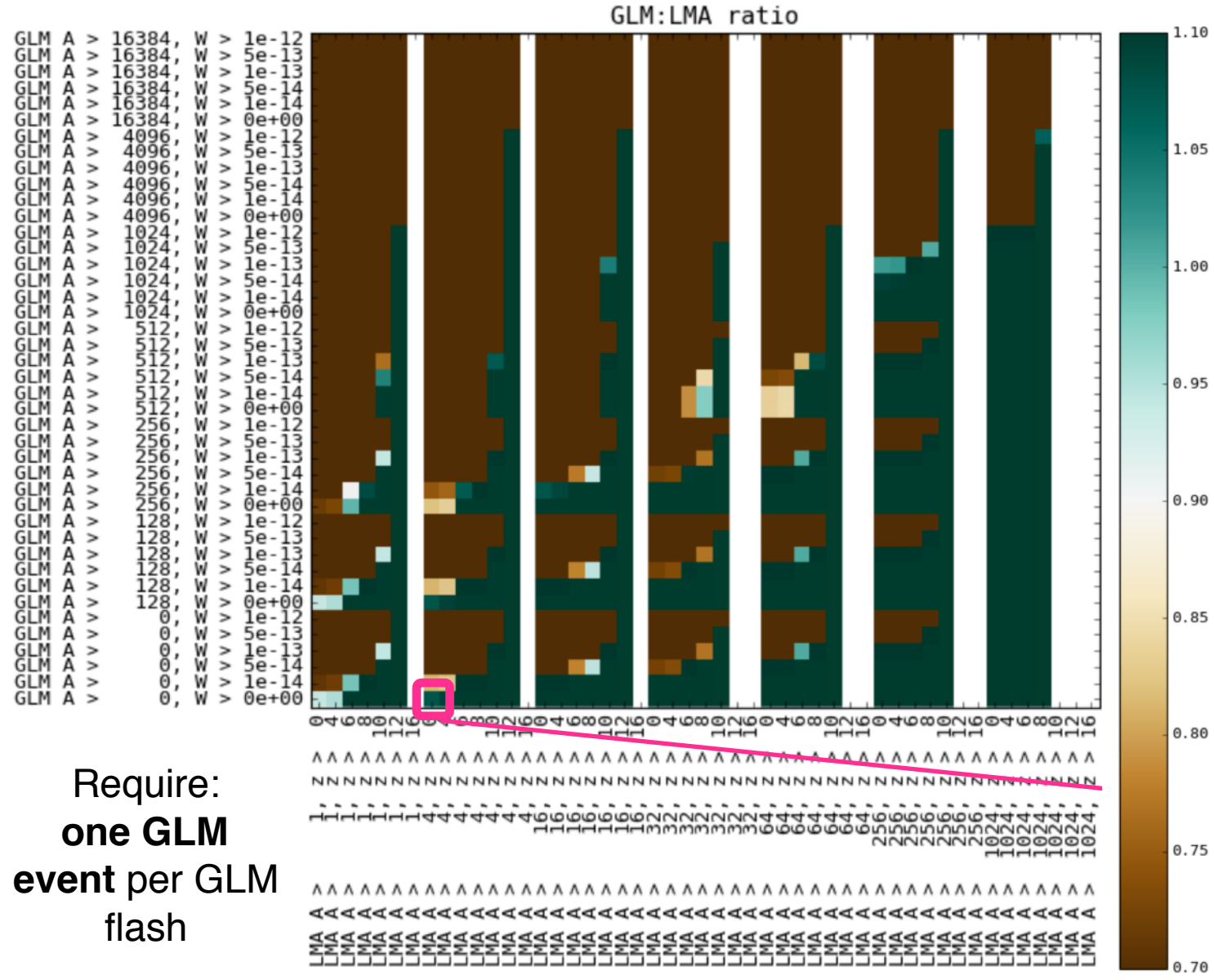
5 July 2017, West Texas (post-PR 04.04.07)
Represents initial state of "beta" data



Require: **one GLM event** per GLM flash

107% DE of all LMA flashes with width > 2 km

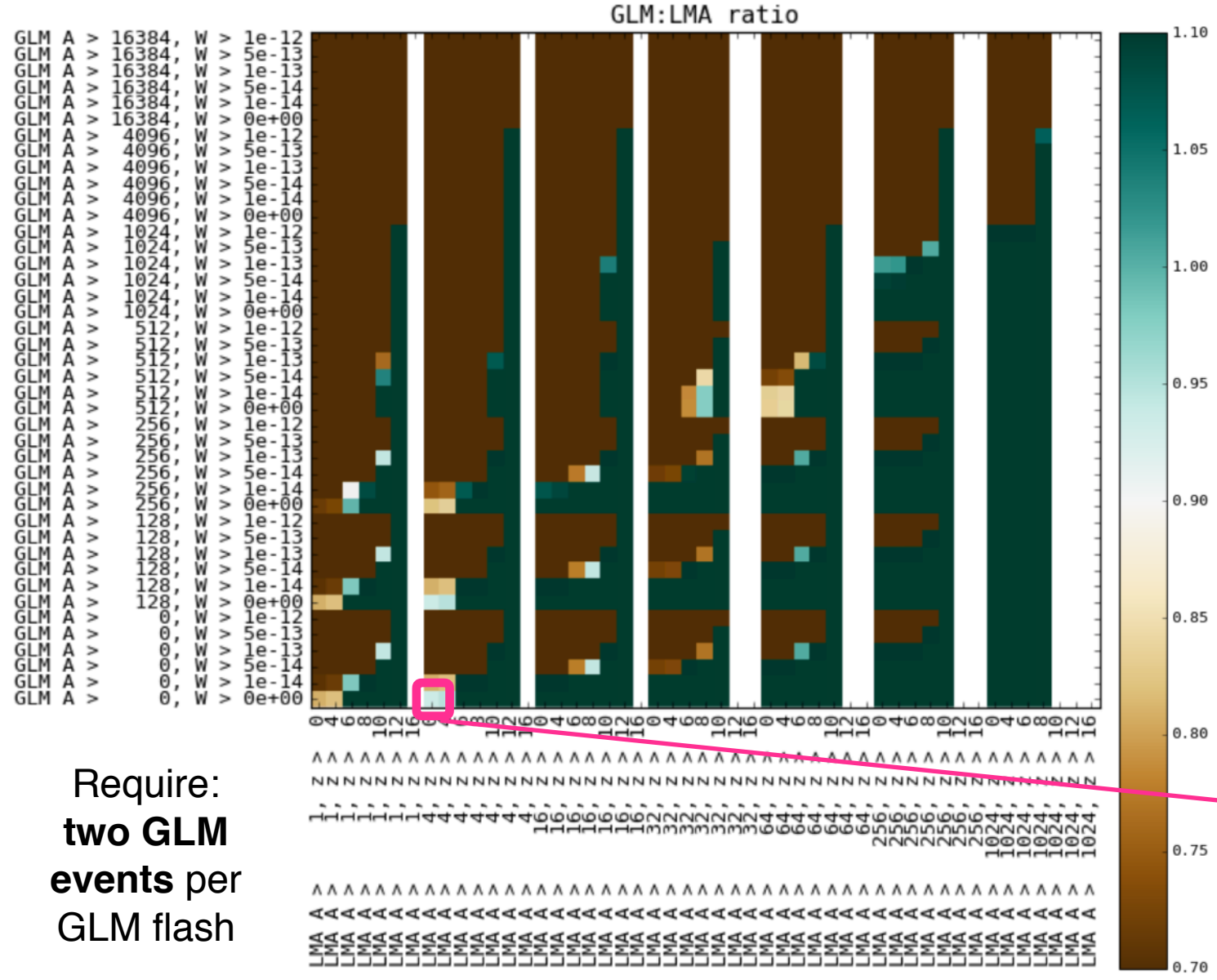
5 July 2017, West Texas (post-PR 04.04.07)
Represents initial state of "beta" data



Require: **one GLM event** per GLM flash

107% DE of all LMA flashes with width > 2 km

5 July 2017, West Texas (post-PR 04.04.07)
Represents initial state of "beta" data

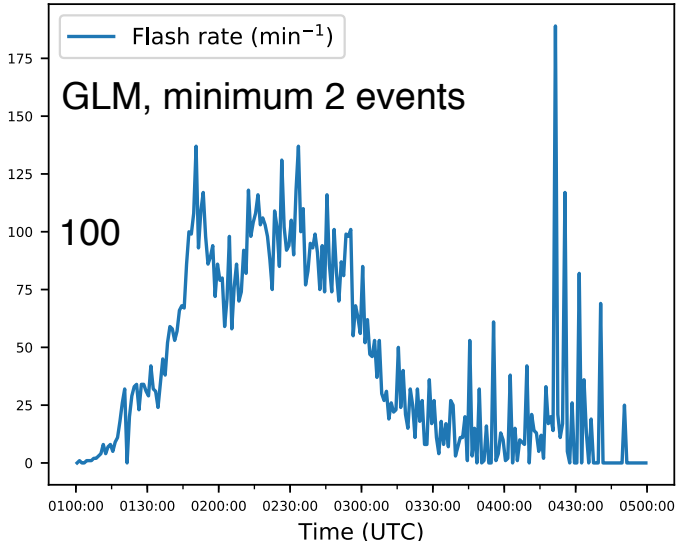


Require: **two GLM events** per GLM flash

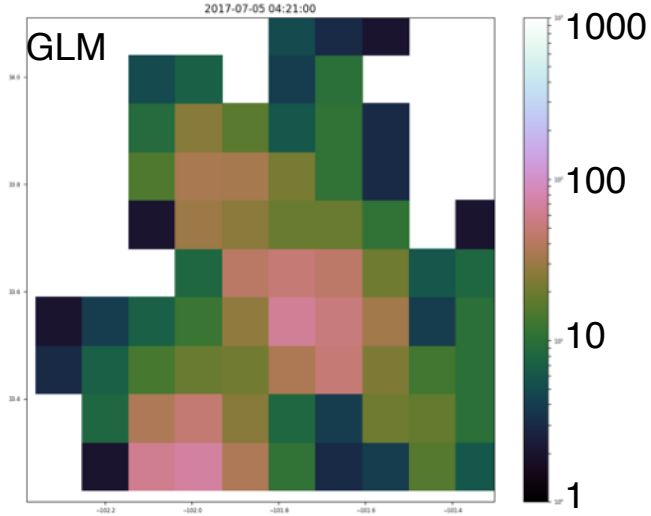
93% DE of all LMA flashes with width > 2 km

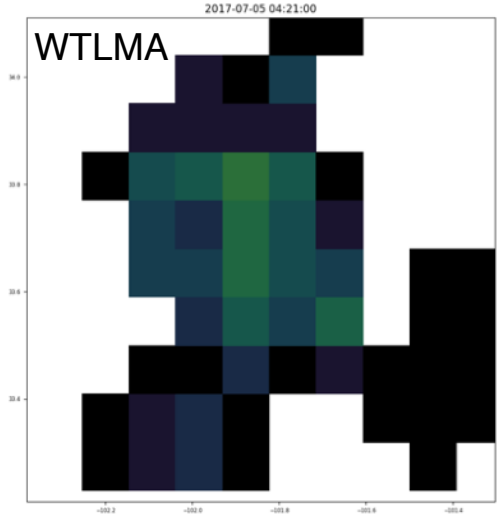
5 July 2017, West Texas
Time series data help spot irregularities

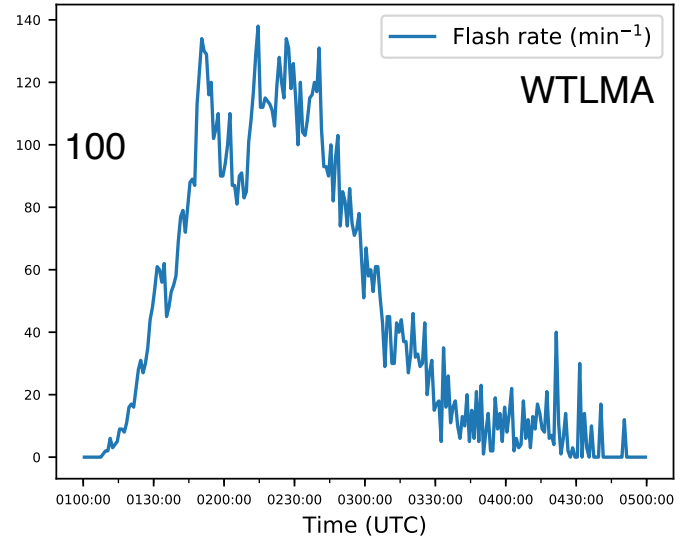
- Initial maximum in flash rates as convective line passes, followed by low flash rate stratiform region
- Spike in stratiform flash rates exceeds that in leading line: unphysical
  - *Many flashes > 4 s duration (manually classified)*
  - *6 s discharge split into ~200 GLM flashes*
    - Details in Mach talk from Tuesday
  - *Most likely a ground system issue? Events look reasonable.*



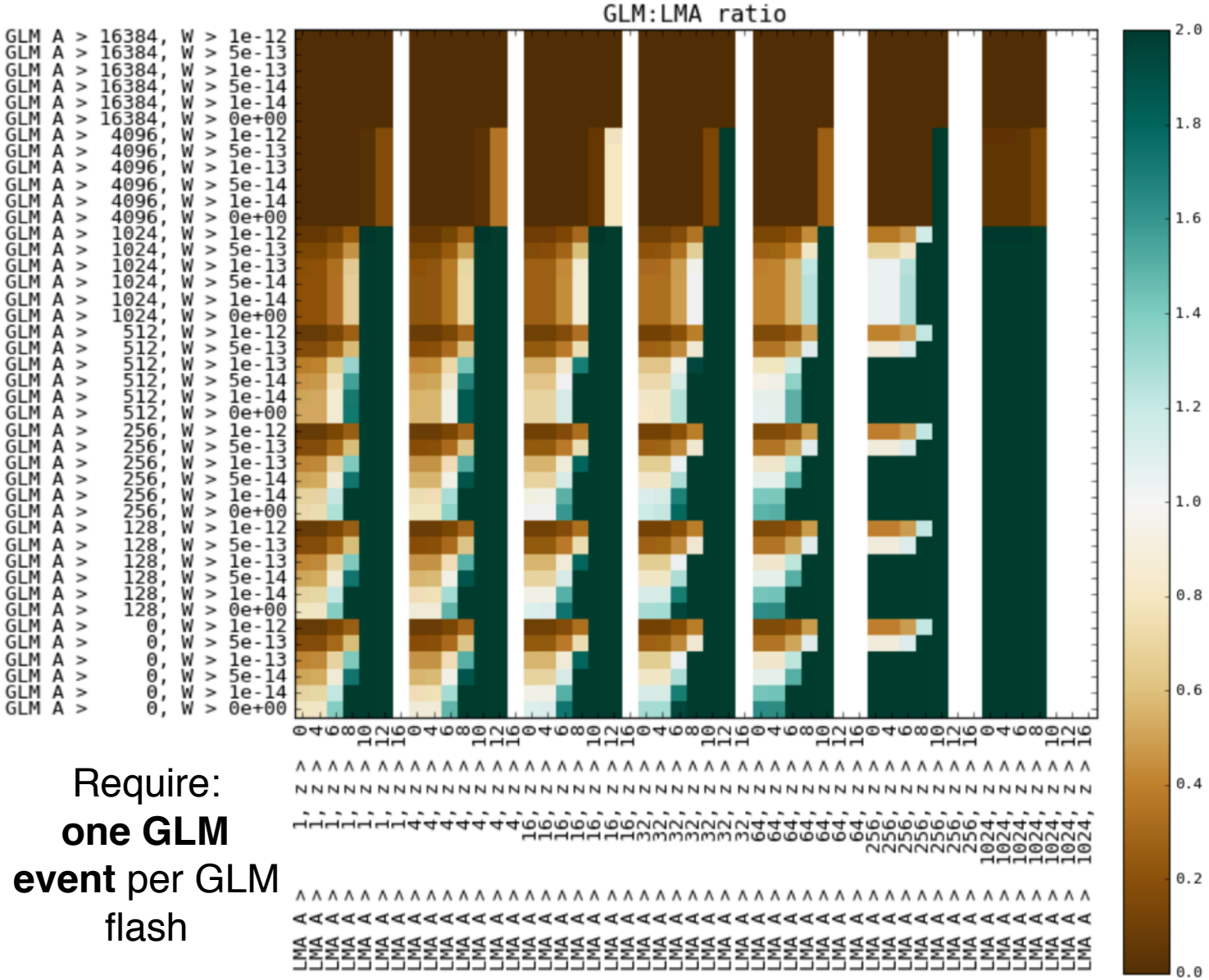
Flash extent density, 0421 UTC







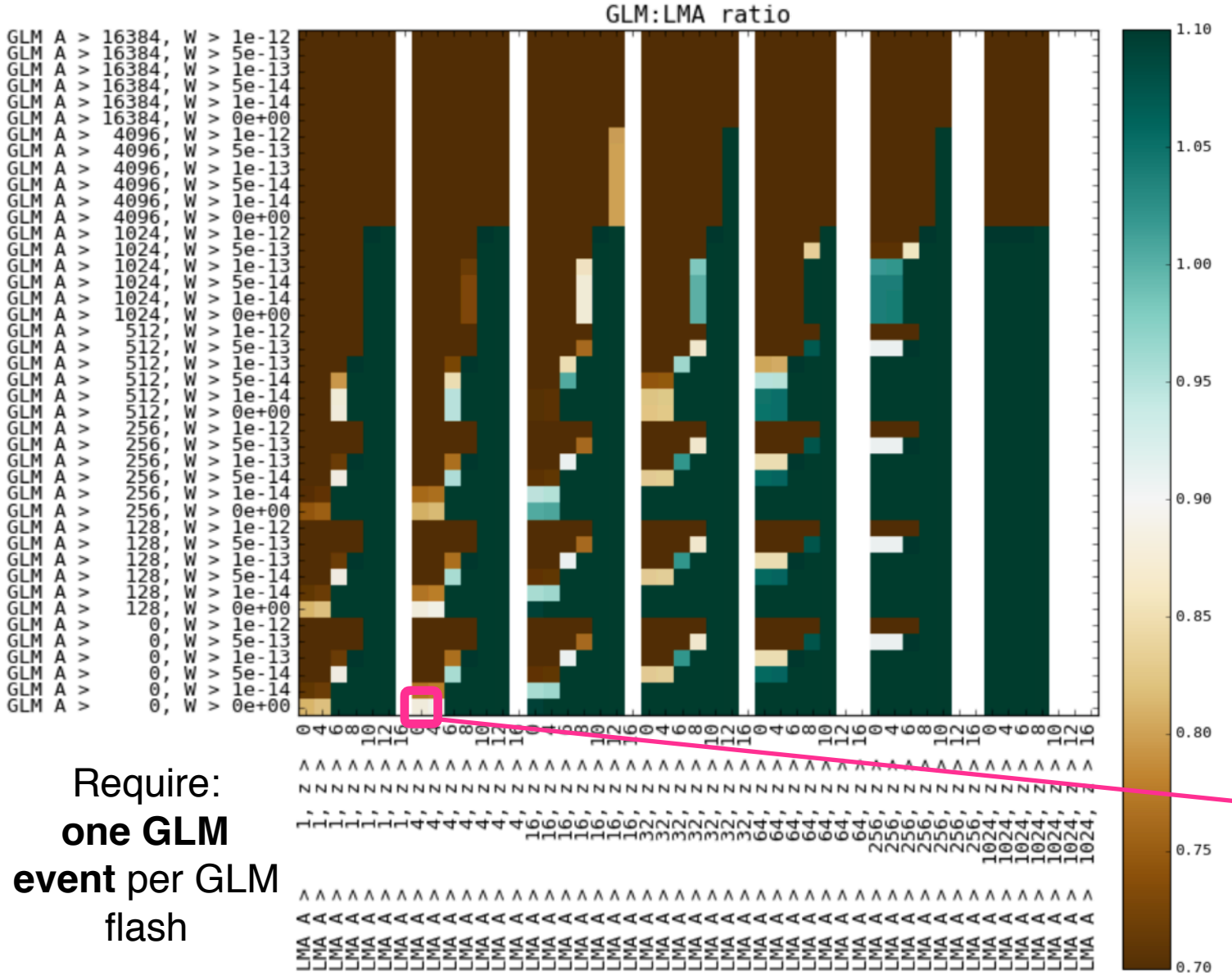
31 July 2017, West Texas (post-DO 05.00.00)
GLM: area & radiant energy
LMA: area & altitude



Require: **one GLM event** per GLM flash

88% DE of all LMA flashes with width > 2 km

31 July 2017, West Texas (post-DO 05.00.00)
GLM: area & radiant energy
LMA: area & altitude



Each area sub-block has a 1:1 sweet spot

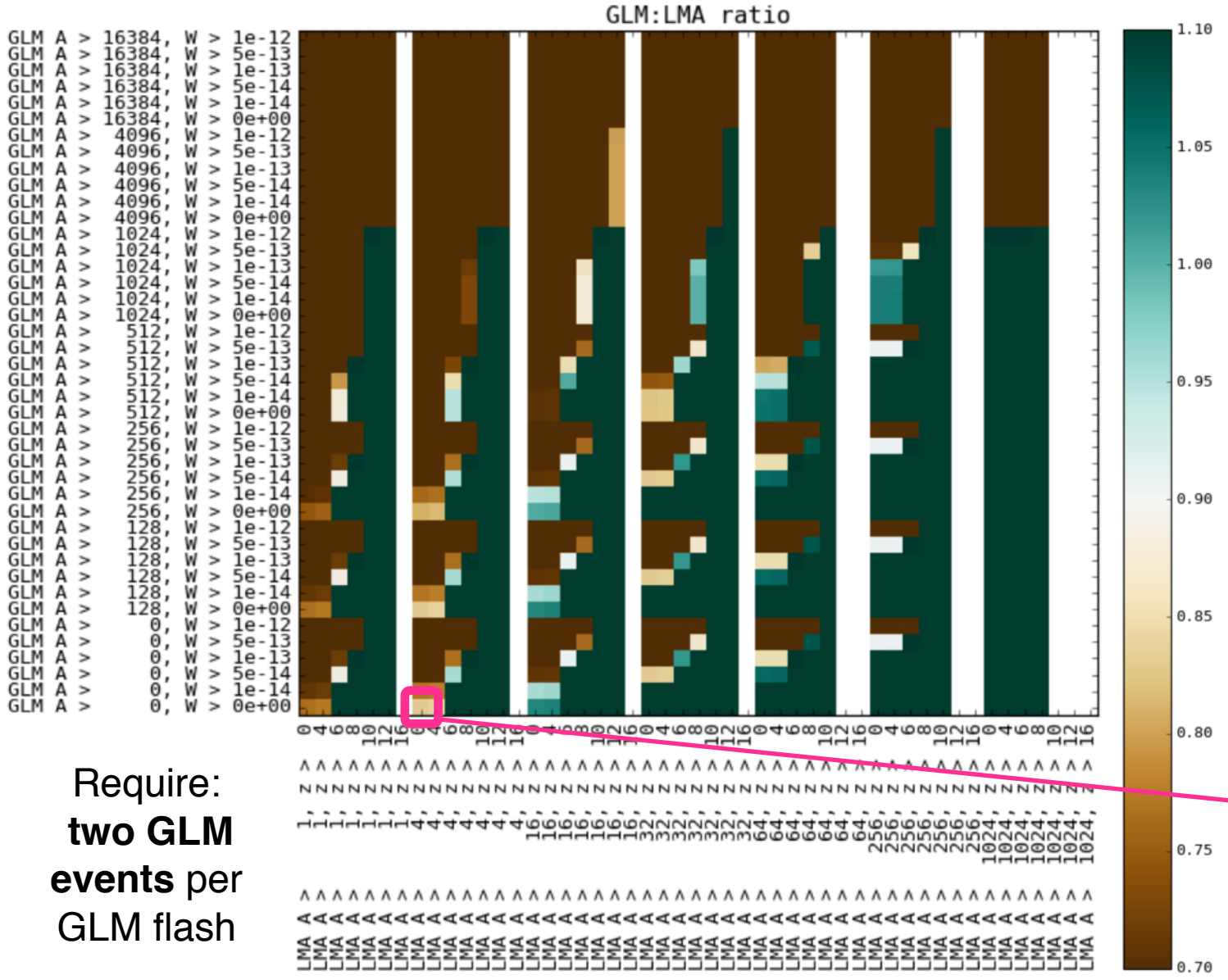
Desired performance is within the parameter space

As expected, some small or low-altitude flashes are not observed by GLM

Require: **one GLM event** per GLM flash

88% DE of all LMA flashes with width > 2 km

31 July 2017, West Texas (post-DO 05.00.00)
GLM: area & radiant energy
LMA: area & altitude



Each area sub-block has a 1:1 sweet spot

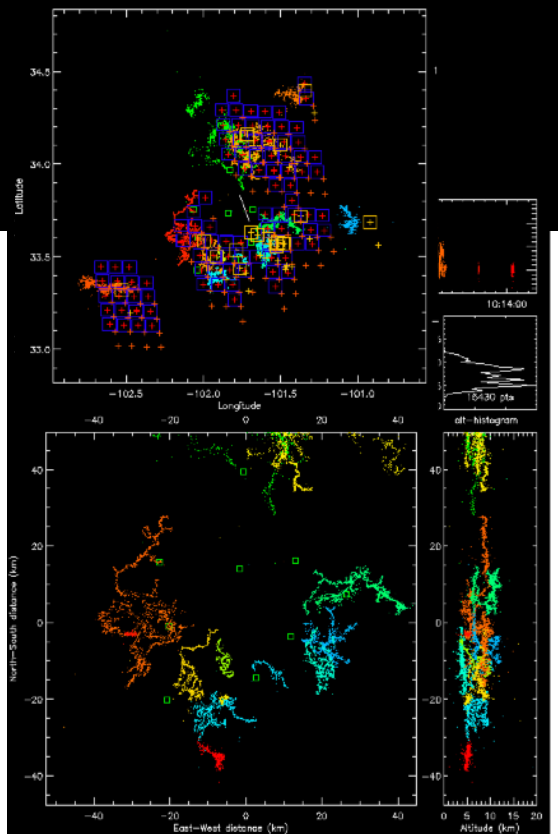
Desired performance is within the parameter space

As expected, some small or low-altitude flashes are not observed by GLM

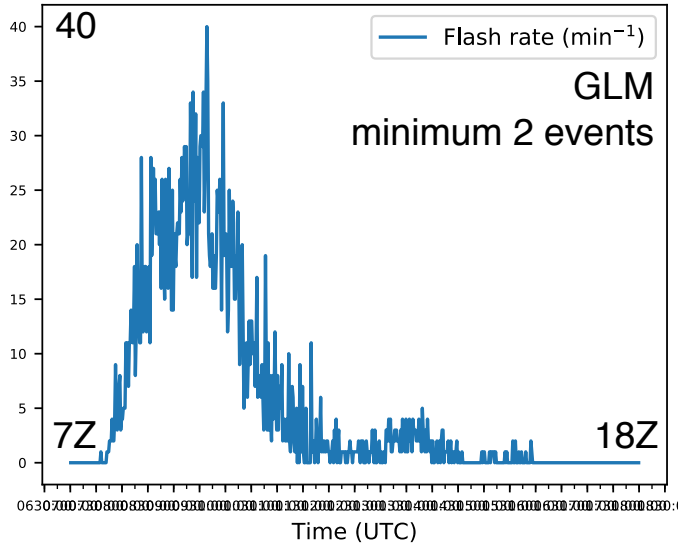
Require: **two GLM events** per GLM flash

83% DE of all LMA flashes with width > 2 km

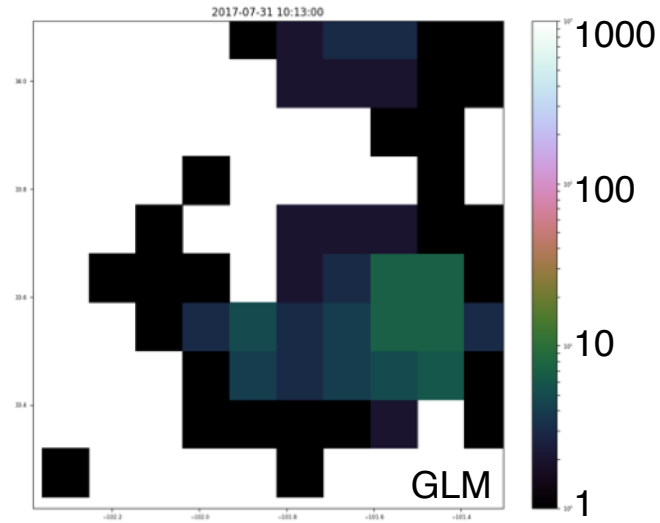
31 July 2017, West Texas
Time series data

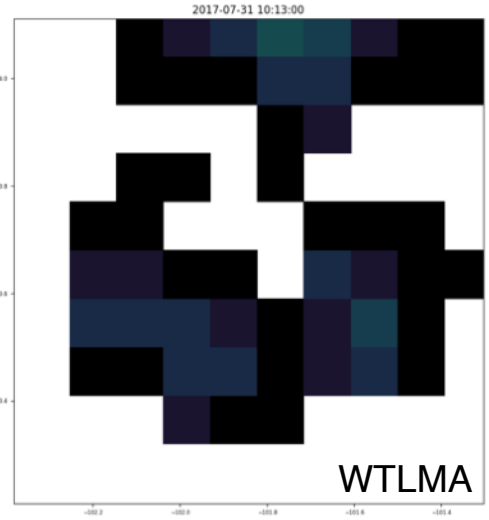


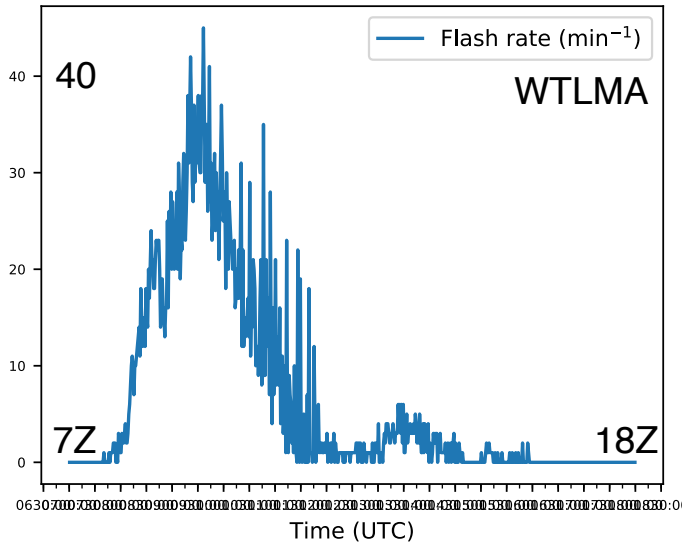
- Initial maximum in flash rates as convective line passes, followed by low flash rate stratiform region
- Unlike July 5, these stratiform flashes lasted about 1 sec
- Southwest offset seems improved
- Shape of extensive flashes obvious in grids



Flash extent density, 1013 UTC







Summary

Bulk processing of GLM and LMA data

- Gridding shows storm cell motion
- Time series shows trends: crucial for meteorological applications

Both approaches suggested deep dives

- identified spatial offsets
- identified odd flash counts

Parameter space approach has been demonstrated

- What is the sensitivity of flash DE to flashes sorted by energetically-relevant parameters?
- Future analyses can focus on lower left quadrant, and vary minimum events and groups per flash

Preliminary evaluation

- The LMA flashes I must discard to match the GLM flash rate are those I expect to be less visible
- GLM time series tracks LMA quite well, especially after removing small LMA flashes
- Keep looking at time series to ensure large flashes are not being split by processing irregularities